April 30, 2014
Taylere M. Bernett
School of Environment and Natural Resources
The Ohio State University
Columbus, OH 43202, USA
513/353-8545
bernett.1@osu.edu

Avian response to feathering habitat edges in an agricultural landscape in southwestern Ohio

TAYLERE M. BERNETT, *School of Environment and Natural Resources, the Ohio State University, Columbus, Ohio 43202 USA*

ABSTRACT Edge feathering is a habitat restoration method that potentially benefits early successional wildlife species. Past studies have shown that it can increase populations of certain game bird species, such as Northern Bobwhite (*Colinus virginianus*). Therefore, it is expected that edge feathering will also lead to increases in edge-inhabiting songbird species. This study evaluates the effect of edge feathering on specific Federal Trust songbird species in Ohio that are of conservation concern. Songbirds were observed using point counts to determine presence and abundance in treated and control sites. Vegetation data was evaluated on all plots by measuring ground cover, horizontal visual obstruction, overhead cover, and shrub density. Fourteen birds had a frequency of occurrence above 10%, and 3 of those are listed as Federal Trust species. Generalized linear models were used to evaluate relationships between these 14 bird species and treatment type, site location, and vegetation characteristics. Most birds did not show associations with edge feathered plots in general. However, the Wood Thrush (*Hylocichla mustelina*), Indigo Bunting (*Passerina cyanea*), Red-bellied Woodpecker (*Melanerpes carolinus*), and Song Sparrow (*Melospiza melodia*) were correlated with specific habitat variables. This supports my

expectation that edge feathering has some impact on presence and abundance of important bird species, and that it may hold potential as a method of habitat restoration. I recommend that the Ohio Department of Natural Resources (ODNR) continue to maintain and evaluate these sites and their impacts on species associated with early successional habitats.

KEY WORDS Edge feathering, Federal Trust, Highland County, Ohio, *Hylocichla mustelina*, *Melanerpes carolinus*, *Melospiza melodia*, *Passerina cyanea*

Transition zones exist between different habitat types in natural landscapes. One of particular importance in the Midwest is that between forests and open land. This is typically an early successional area consisting of thick undergrowth, shrubs, and small trees. Active management is needed to conserve these transition areas because they provide important habitat for many wildlife species, especially songbirds. Studies show that increased species richness and a higher density of birds are found in transition zones, also called ecotones. This is because ecotones have a combination of the characteristics that make up both habitats, as well as some that are unique to the transition area itself (Gates and Gysel 1978).

Unfortunately, many early successional areas have been lost due to human activities. These include land use changes, such as clearing for agriculture or residential areas, as well as succession brought about by changes in the disturbance regime. Early successional areas are often left to mature without some level of intermediary disturbance (Greenfield et al. 2002). This maturation process only takes about ten to fifteen years, after which the habitat is no longer considered early successional. Disturbances used to be caused largely by naturally occurring fires, or those used by Native Americans to manage forests. However, as lands became more developed and were used for different purposes, people began suppressing fires, leading to a lack of disturbance. Compounding this, public attitudes have changed about timber harvests, which

have contributed to this decline. There are negative connotations among the public associated with using even-aged harvest methods (e.g., clear-cutting), and support has grown for decreasing harvest on public lands and allowing forests to mature and expand. This has all contributed to an overall decrease in early successional habitat (Dessecker and McAuley 2001).

This is a major issue for songbirds that depend on early successional habitat for survival. Many of these birds are Federal Trust species, which are birds that the U.S. Fish and Wildlife Service designates as priority species for conservation. These include birds that are rare or declining, such as the Henslow's Sparrow (*Ammodramus henslowii*) and Field Sparrow (*Spizella pusilla*), or those that are financially important to a specific area (e.g., game birds) (U.S. Fish & Wildlife Service 2012). It also includes birds that may have stable populations, but they are important ecologically, such as the Mourning Dove (*Zenaida macroura*), Orchard Oriole (*Icterus spurius*), Indigo Bunting (*Passerina cyanea*), and Carolina Wren (*Thryothorus ludovicianus*) (USFWS 2013, The Cornell Lab of Ornithology 2011). Unfortunately, some birds that depended on early successional habitats have already become extinct. These include the Greater Prairie-chicken Heath Hen (*Tympanuchus cupido cupido*), Passenger Pigeon (*Ectopistes migratorius*), Carolina Parakeet (*Conuropsis carolinensis*), and the Dusky Seaside Sparrow (*Ammodramus maritimus nigrescens*) (Hunter et al. 2001).

Survival becomes more difficult for edge-dependent bird species as their habitats are degraded. The plants they depend on are removed or crowded out by larger trees or invasive species. In addition, they become more exposed to predators and nest parasites, such as the Brown-headed Cowbird (*Molothrus ater*) (Hoosier Heartland Resource Conservation and Development Council 2007). Bird species of conservation concern are important economically

and ecologically (e.g., seed dispersal, insect population control), so it is imperative that wildlife managers make efforts to help them survive (Gates and Gysel 1978).

A recent method being utilized to combat these problems is called edge feathering, which attempts to increase early successional habitat and create a more gradual transition between forest and open land. Managers can employ different methods to accomplish this. One is to plant lower-growing woody (e.g., shrubs, vines) and herbaceous (e.g., briars, wildflowers, grasses). Another is to cut down some of the larger-diameter trees and mid-story vegetation along a forest edge. Either method allows early successional vegetation to take advantage of the available resources and recolonize the area. In addition to providing structural habitat, these plants also provide food for many songbirds, both directly through increased seed, nut, and berry production, as well as indirectly through increased insect numbers (Kentucky Dept. of Fish and Wildlife Resources 2012, Hoosier Heartland Resource Conservation and Development Council 2007).

An alternative to edge feathering is utilizing prescribed fire to simulate the natural processes that would return forest and grassland edges to an earlier successional state. However, this method is not always a viable option. The land in question may be too close to residential or agricultural areas to safely implement this procedure (Dessecker and McAuley 2001). Man-made edges, often created in the process of clearing land, are usually too narrow to be adequate habitat for the birds that attempt to live there. Studies have shown that these edges are in fact “ecological traps” (Gates and Gysel 1978). This means that birds are attracted to them because they seem to have the proper features of quality edge habitat, but they in fact put these birds at a greater risk of predation and nest parasitism. Not only do songbirds have fewer places to hide, but these birds

also become more concentrated in a smaller area, making them easier to find and drawing in more predators (Gates and Gysel 1978).

Increased shrub cover, a benefit related to edge feathering, has shown to be effective in reducing brood parasitism. Research by Budnik et al. (2002) on Bell's Vireo (*Vireo bellii*) indicated that shrub cover provided more nesting area and made Vireo nests more difficult to find, decreasing the ability of Cowbirds to parasitize nests. Similarly, greater cover also decreased nest predation because shrub cover makes searching for Vireos and other vulnerable birds more difficult. Based on these results, it is suggested that managers increase size and density of shrub patches in grassland habitats, which is what edge feathering attempts to do.

Studies have shown that improving edge habitats has increased populations of some bird species, including some that are Federal Trust species. Data collected in Mississippi on edge feathered sites showed an increase in Bobwhite numbers from less than one per 50 ha of land to about 2 per ha in a span of five years (Brennan 1991). Bobwhite populations have also increased on crop lands that have been converted into grasslands, along with those of other species that utilize these areas for breeding and wintering habitats, such as Tree Sparrows (Best et al. 1998). Improving early successional habitat has increased Ruffed Grouse (*Bonasa umbellus*) and American Woodcock (*Scolopax minor*) numbers, both of which are economically important species that require this habitat type (Dessecker and McAuley 2001). If improving edge habitat can lead to population increases in these species, it is reasonable to believe that other edge-dependent species will show population increases from similar management actions as well.

In order prevent further species declines and improve numbers for more species, it is vital that managers work to preserve and increase early successional habitat. By studying edge feathered areas in Highland County, Ohio and documenting presence of these federal trust

species, I will evaluate the effectiveness of edge feathering. If these species are found in these areas, it can be reasoned that edge feathering holds potential as a conservation tool for more than just game species.

There are two main objectives of this study. The first is to document presence and abundance of Federal Trust species on edge feathered sites in Highland County, Ohio. The second objective of this project is to evaluate which habitat conditions are most closely associated with the presence of early successional bird species. Variables that will be analyzed include treatment type (i.e., edge feathered vs. control plots), site location (Fee and Peach Orchard), and specific vegetation characteristics that differ between treated and untreated plots (e.g., shrub cover and density). I expect that Federal Trust species will be present on my study sites and that species composition will differ between treated and control plots. I also expect the presence of early successional bird species to be positively correlated with feathered edges and with specific characteristics of treated areas, such as increased ground cover and shrub density.

STUDY AREA

My study was carried out on two pre-treated sites in Highland County in southwestern Ohio, just outside of the city of Hillsboro. This is in the till plain region of the state, which is characterized by a fairly hilly landscape (Ohio Division of Geological Survey 1998). The study sites are called "Fee" and "Peach Orchard", and are 1,358 ha and 398 ha, respectively (Fig. 1). They comprise multiple tracts of privately owned land, and contain livestock pastures, crop fields, Conservation Reserve Program (CRP) fields, and wooded areas. The crop fields are planted mostly with corn and soybeans, though some fields are used for winter wheat, hay, and tobacco. The CRP fields are dominated by warm season grasses, and the forests are dominated by deciduous trees,

including black walnut (*Juglans nigra*), ash (*Fraxinus* spp.), and oak species (*Quercus* spp.) (U.S. Department of Agriculture 2013).

METHODS

Site Selection

Eighty-nine plots were edge feathered on these lands during the Springs of 2012 and 2013 by cutting down mature forest vegetation. These sites were treated as part of an ongoing research project studying Northern Bobwhite populations in the area. This project is funded by the Ohio Department of Natural Resources (ODNR) and the U.S. Fish and Wildlife Society (USFWS). Each plot measured 100ft X 30ft. I recorded observations of presence and abundance of songbirds on 46 edge feathered plots [17 on the Fee site (Fig. 2), 29 on the Peach Orchard site (Fig. 3)]. Thirty-two of these were "old" sites, meaning that they were feathered in 2012, and fourteen of these were "new" sites, having been feathered in 2013. This impacted the amount of vegetation that had regenerated on the plots, but was accounted for in the data analysis by comparing bird presence to specific vegetation characteristics. Observations were also conducted on 23 control plots [12 on the Fee site (Fig. 2), 11 on the Peach Orchard site (Fig. 3)]. Both treated and control sites were located on the edges of woodlots that bordered either agricultural fields (50% of plots) or fallow fields (50% of plots). Control plots were located $\geq$ 200 m from treated plots to avoid overlap of observations. Attempts were made to place control plots along the same edge as treated plots, but sometimes this was not possible because many of the wooded areas were severely fragmented.

Songbird Observations

I recorded observations during 3 time periods: June 4 – June 15, June 17 – July 2, and July 31 – August 13. This allowed me to compare results during breeding and post-breeding seasons to see if this impacts which species are present. I conducted point counts to observe presence and abundance of songbirds from a location 15 m away from the edge, as close to the center of the edge feather as possible, using a plot radius of 75 m. This was done from about 0600 – 1000, which is when songbirds are most active. A one minute rest period was allowed at each site for the adjustment of bird activities, and each point count lasted for five minutes. Point counts were not conducted during heavy precipitation events (more than a light sprinkling) or if the wind exceeded 21 km/h. The number of sites visited each day depended on how long it took to travel from one to the next, and surveys were conducted on $\geq$ four days a week.

The order in which sites were visited was randomized for each round of surveys to avoid temporal bias. Birds were identified by sight and sound, and I recorded distance and time to detection, prevent observational duplication of the same bird multiple. A sample data collection sheet has been prepared (Fig. 4). I attempted to identify and record presence and abundance of all bird species within the observation areas; however, data analysis focused on Federal Trust species (Appendix Table 1).

Vegetation

Vegetation data was previously collected on treated sites by Coree Brooks, a graduate student in the School of Environment and Natural Resources (SENR) at the Ohio State University, who is studying the impact of edge feathering on Northern Bobwhite populations in the area. I collected vegetation data on untreated sites throughout the time frame of my study. This was collected within a plot measuring 15.48 m by 9.14 m at the forest edge of each study plot. The diameter at breast height (DBH) of each tree larger than 5 cm was recorded to the nearest 0.5 cm with a

metric d-tape, along with the species of the tree. Basal area was then calculated for data analysis. An overhead cover, or "cone-of-vulnerability" (COV), measurement was taken at each plot center using a 2 m PVC pipe to evaluate how well vegetation would conceal birds from aerial predators (Higgins et al. 2005). Measurements were taken in four directions at 90° angles, the first of which was perpendicular to the plot edge, and vegetation below 0.3 m was not recorded. Horizontal visual obstruction was measured in the same four directions at plot center with a profile board (Higgins et al. 2005). Obstruction was recorded into 1 of 7 cover classes (0%, >0-5%, >5-25%, >25-50%, >50-75%, >75-95%, and >95%). Ground cover was evaluated using a Daubenmire frame at plot center and in the above mentioned 4 directions, 2 m from plot center. The cover classes used were the same as those used for visual obstruction and cover categories included bare ground, ground litter, grasses and sedges, forbs, shrubs, brush, and "other". Shrub density for Amur honeysuckle (*Lonicera maackii*), multiflora rose (*Rosa multiflora*), *Rubus* spp, and the overall closest species was measured using the point-centered quarter method. A maximum radius of 10 m was used for each quadrant (Higgins et al. 2005).

Data Analysis

Statistical analyses were conducted using the program R (R core team 2013). I ran a series of generalized linear models to find associations between individual bird species and treatment type, site location, and specific vegetation variables (visual obstruction, overhead cover, shrub density). These were primarily logistic models that analyzed the interactions between two or more of the independent variables (e.g., treatment type by site and treatment type by vegetation characteristics) and their associations with individual bird species presence. Only species with a frequency of occurrence $\geq$ 10% were analyzed with these models. I also ran a Poisson regression to compare total bird abundance to these same independent variables.

RESULTS

Fifty-one total bird species were identified during this study (Table 1). Fifteen of these species had a frequency of occurrence $\geq$ 10% throughout the survey period (only 14 species were analyzed; the Northern Bobwhite was left out because it is already being studied thoroughly by graduate students). Vegetation data collected shows that there are some drastic differences in the average horizontal visual obstruction and overhead cover between treated and untreated plots (Table 2), as well as some differences among plots of the same treatment type (Appendix Tables 2 and 3).

No significant relationship was found between the 14 bird species analyzed and the treatment type when controlling for variation by site location (Table 3). There were also no significant relationships between total bird abundance and any of the variables analyzed when running the Poisson regression models (Table 4). All P-values resulting from these analyses were $\geq$ 0.1. However, some significant relationships occurred between individual bird species and specific vegetation variables based on treatment type. Wood Thrushes were less abundant on edge feathered plots ($p = 0.029$). Indigo Buntings were more prevalent in plots with greater horizontal visual obstruction values ($p = 0.0471$), but were negatively correlated with higher shrub densities ($p = 0.0151$). Red-bellied Woodpeckers ($p = 0.0482$) and Song Sparrows ($p = 0.0492$) showed a significant positive correlation with shrub density (Table 5).

DISCUSSION

The results of my study are not as definitive as I expected them to be. However, it is possible to draw some conclusions about the relationships between Federal Trust species and edge feathered

habitats. My expectations were somewhat supported. Many edge-dependent and/or Federal Trust species were found on my study sites. The Blue Jay, Common Yellowthroat, Eastern Towhee, Field Sparrow, Gray Catbird, and Indigo Bunting tend to prefer early successional habitat. The Eastern Wood-pewee, Northern Flicker, and Song Sparrow utilize these habitats along with interior forests, and Wood Thrushes sometimes nest in shrubs or small trees (The Cornell Lab of Ornithology 2011). The presence of these species indicates that the feathered edges on the Fee and Peach Orchard sites have some attractive habitat characteristics. Though not all are listed as Federal Trust species, some have been declining enough that biologists have taken notice [e.g., Common Yellowthroat, Eastern Towhee, and Indigo Bunting (The Cornell Lab of Ornithology 2011)]. Therefore it is important to note that these species, along with the more noticeably declining species (i.e., Field Sparrow, Northern Flicker, and Wood Thrush), utilize the area.

Some of the associations between specific bird species and treated plots also support my expectations. The significant negative correlation between Wood Thrushes and treated plots indicates that edge feathered areas offer different habitat attributes than untreated sites because Wood Thrushes mostly favor contiguous forests (The Cornell Lab of Ornithology 2011). This conclusion is further supported by the fact that Indigo Buntings and Song Sparrows were more abundant on sites with denser understory vegetation; Indigo Buntings forage, nest, and perch in shrubs to sing, and Song Sparrows nest in shrubs, grasses, and weeds (The Cornell Lab of Ornithology 2011). Though the results of this study do not show overwhelming evidence that edge feathering is having a major impact in this area, the findings still indicate a positive outlook for some declining edge species.

Some of my results were unexpected and warrant further investigation. The negative correlation between Indigo Buntings and shrub density and the positive correlation between Red-

bellied Woodpeckers and shrub density may have been influenced by changes in my ability to detect birds based on vegetation density. The overall lack of significant relationships may be related to the brevity of the study or other variables (e.g. weather conditions, timing of vegetation data collection, basal area, etc.) that were not analyzed due to time constraints. Running more thorough statistical tests may reveal relationships that were not otherwise seen in this study.

Another issue of concern that should be explored is invasive plants. Edge feathering can help establish native plants if managed correctly, preventing destructive invasives from taking their places at abrupt forest edges. This further benefits species of concern because invasive plants do not provide the ideal habitat created by native plants (Hoosier Heartland Resource Conservation and Development Council 2007). Invasive plants are easiest to control when edge feathering is done by planting vegetation to create an early successional area. However, if feathering is done by cutting down trees, opportunistic invasives are more likely to become established. In this case, managers would need to monitor the species composition of regenerating vegetation and replace invasives with native species (Hoosier Heartland Resource Conservation and Development Council 2007).

Further research on edge feathered sites in Highland County, OH may shed more light on whether this habitat restoration method is benefiting edge species. Some of these plots have only recently been treated, so they may not have had time to establish all of the necessary characteristics that edge-dependent species require. Invasive plants may also be impacting habitat quality, so their presence and density should be evaluated. Though this study was only carried out during a period of three months, more significant results can be expected if it were continued over a span of multiple years. Data should be collected on variables such as clutch size and fledgling success to determine if bird survival rates are improving over time as edge habitats

are maintained over the long term.

MANAGEMENT IMPLICATIONS

Managers should consider the results of this study to be a positive starting point to further evaluate edge feathering as an effective habitat restoration method. Early successional Federal Trust bird species were present on treated plots, and some had statistically significant positive relationships with feathered edges. I recommend that treated sites be maintained and reevaluated on a regular basis. The ODNR should focus on increasing horizontal visual obstruction and shrub density within feathered edges and actively promote native vegetation, especially species that attract Federal Trust birds. Edge feathered lands in Highland County have the potential to be valuable habitat for declining early successional bird species, and I believe conservation efforts should continue here.

ACKNOWLEDGMENTS

I thank Dr. Robert Gates for offering me the opportunity to carry out this study as part of his ongoing research on the effects of edge feathering in Highland County, OH. He provided guidance on all the important steps of the study, including background, methods, and data analysis. Coree Brooks and Randy Knapik offered instruction on specific data collection procedures and provided data sheets and equipment. All of the landowners that allowed treatments and research to be carried out on their fields and woodlots made this study possible. Dr. Kristi Lekies and Dr. Gabriel Karns provided additional review comments to help me improve this paper. Finally, I thank the Ohio State University, the Ohio Department of Natural Resources, the U.S. Fish and Wildlife Service, and Pheasants Forever for funding, housing, and

use of vehicles for travel between sites.

LITERATURE CITED

Best, L. B., H. Campa, K. E. Kemp, R. J. Robel, M. R. Ryan, J. A. Savidge, H. P. Weeks, and S. R. Winterstein. 1998. Avian abundance in CRP and crop fields during winter in the Midwest. The American Midland Naturalist 139:311-24.

Brennan, L. A. 1991. How can we reverse the northern bobwhite population decline? Wildlife Society Bulletin 19:544-55.

Budnik, J. M., F. R. Thompson, III, and M. R. Ryan. 2002. Effect of habitat characteristics on the probability of parasitism and predation of bell's vireo nests. The Journal of Wildlife Management 66:232-39.

Dessecker, D. R., and D. G. McAuley. 2001. Importance of early successional habitat to ruffed grouse and American woodcock. Wildlife Society Bulletin 29:456-65.

Gates, E., and L. W. Gysel. 1978. Avian nest dispersion and fledging success in field-forest ecotones. Ecology 59:871-83.

Greenfield, K. C., L. W. Burger, Jr., M. J. Chamberlain, and E. W. Kurzejeski. 2002. Vegetation management practices on conservation reserve program fields to improve northern bobwhite habitat quality. Wildlife Society Bulletin 30:527-38.

Higgins, K.F., K. J. Jenkins, G. K. Clambey, D. W. Uresk, D. E. Naugle, J. E. Norland, and W. T. Barker. 2005. Vegetation Sampling and Measurement. Pages 524-553 in C. E. Braun, editor. Techniques for Wildlife Investigations and Management. The Wildlife Society, Bethesda, USA.

Hoosier Heartland Resource Conservation and Development Council. 2007. Edge Feathering

Fact Sheet. <http://www.hancockswcd.org/attachments/Edge_Feathering_Fact_Sheetfinal.pdf>. Accessed 19 Feb 2013.

Kentucky Department of Fish and Wildlife Resources. 2012. Edge Feathering. < http://www.fw.ky.gov/edge.asp>. Accessed 12 April 2013.

Ohio Division of Geological Survey. 1998. Physiographic regions of Ohio: Ohio Department of Natural Resources, Division of Geological Survey, page-size map with text, 2 p., scale 1:2,100,00.

R Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

The Cornell Lab of Ornithology. 2011. All About Birds. <http://www.allaboutbirds.org/Page.aspx?pid=1189>. Accessed 19 Feb 2013.

Ohio Division of Geological Survey. 1998. Physiographic regions of Ohio: Ohio Department of Natural Resources, Division of Geological Survey, page-size map with text, 2 p., scale 1:2,100,00.

U.S. Fish and Wildlife Service. 2012. Ecological Services. <http://www.fws.gov/>. Accessed 19 Feb 2013.

U.S. Department of Agriculture. 2013. 2013 CDL, Highland County, Ohio. <http://www.nass.usda.gov/Statistics_by_State/Ohio/Publications/Cropland_Data_Layer/2013/CDL_2013_Highland.pdf>. Accessed 29 Apr 2014.

U.S. Fish & Wildlife Service. 2012. Strategic Habitat Conservation. <http://www.fws.gov/southeast/shc/2012workshops/Step%203%20-%20Determine%20Species.pdf>. Accessed 28 Apr 2014.

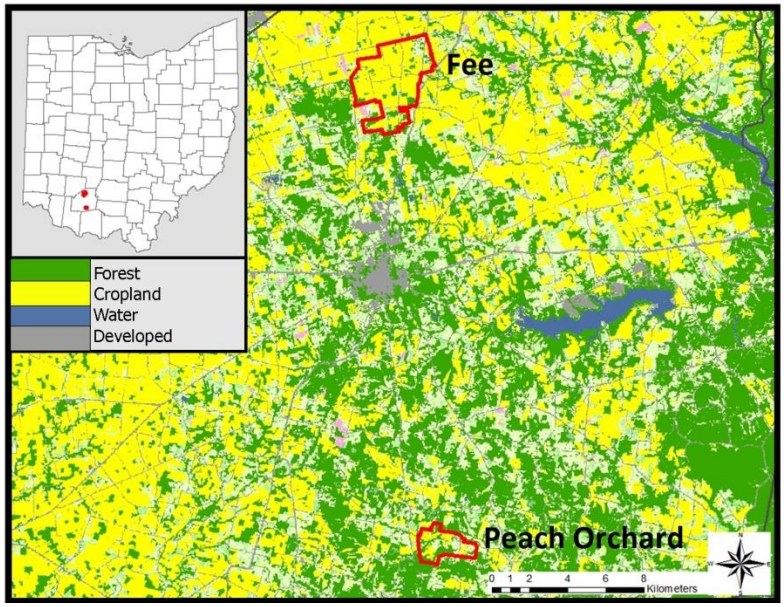

Figure 1: Map of study site locations Fee and Peach Orchard for songbird surveys in Highland County, Ohio during June-August of 2013.

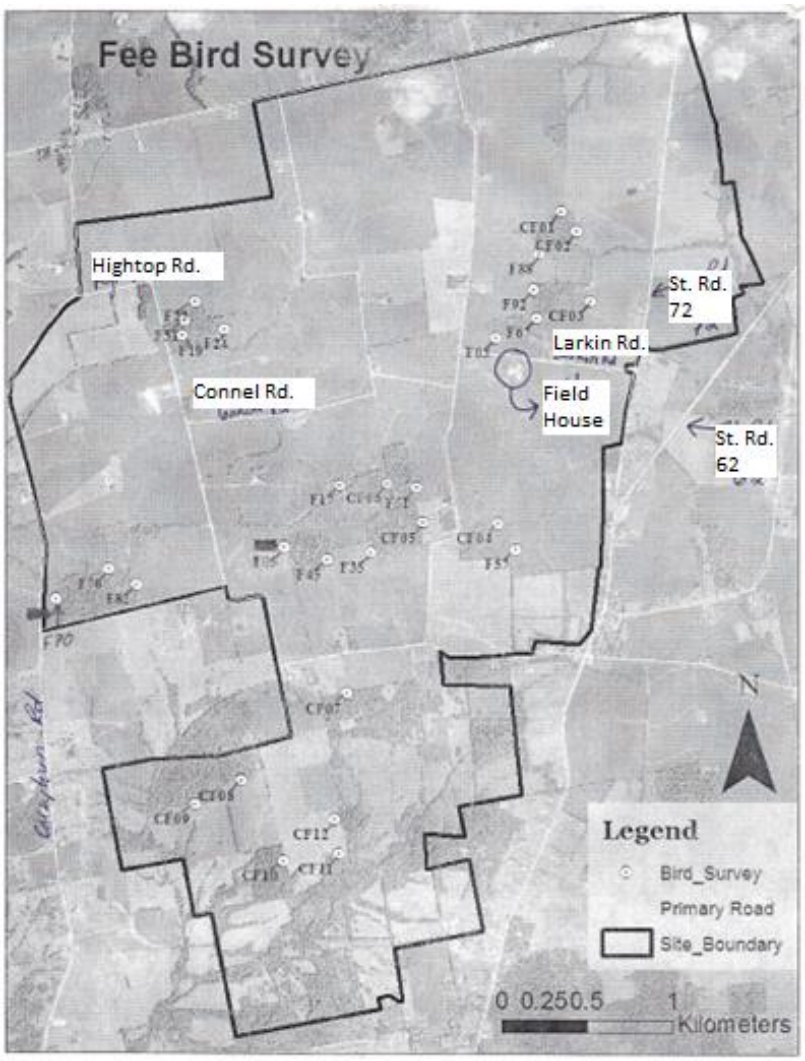

Figure 2: Edge feathered and control plots on the Fee study site in Highland County, OH used for songbird surveys during June-August of 2013 (plots labels starting with a "C" indicate control plots).

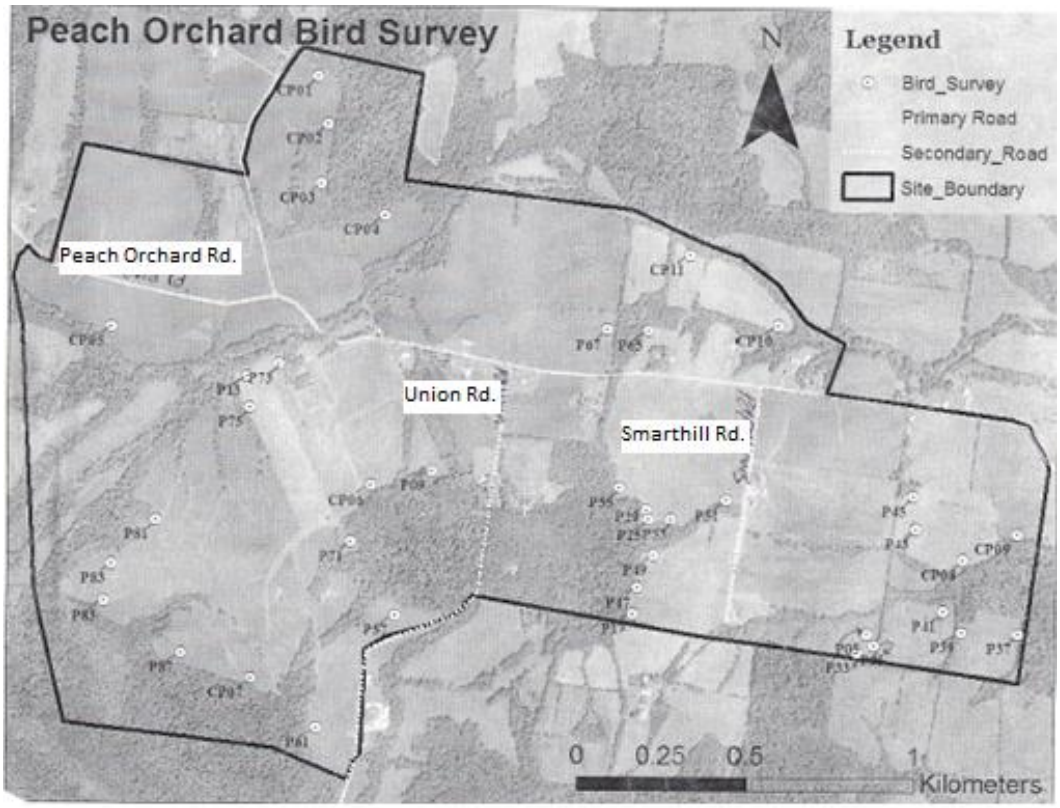

Figure 3: Edge feathered and control plots on the Peach Orchard study site in Highland County, OH used for songbird surveys during June-August of 2013 (plots labels starting with a "C" indicate control plots).

Edge-feathering Bird Survey Data Sheet				Surveyor:			
		Start Time:			End Time:		
Point #	Site Name	Date	Temp	Wind	Sky	Other	
Time Interval	Species	**S**ong/**C**all **SI**ght, **D**rum	Sex (**M**, **F**, **U**)	Distance (10 m)	**F, FE, H, FI** F=forest, FE=forest edge, H=harvest, FI = field		
						Sky Code:	
						0	few clouds
						1	partly cloudy
						2	cloudy
						4	fog/smoke
						5	drizzle
						6	snow
						Wind Code:	
						0	calm
						1	1-3mph
						2	4-7mph
						3	8-12mph
						4	13+ No Sur.
						Other Notes	

Figure 4. Sample data collection sheet to record bird species observed, weather conditions, time and distance to detection, time of day, and site at which observations were conducted for songbird surveys in Highland County, OH during June-August of 2013.

Songbird Species	Total Abundance	Frequency of Occurrence	Songbird Species	Total Abundance	Frequency of Occurrence
Acadian Flycatcher*	5	0.024	Indigo Bunting	120	0.449
American Crow	21	0.082	Kentucky Warbler*	16	0.077
American Goldfinch	13	0.048	Killdeer	4	0.019
American Robin	124	0.478	Mourning Dove*	10	0.043
Barn Swallow	8	0.029	Northern Bobwhite*	39	0.164
Blue-gray Gnatcatcher	1	0.005	Northern Cardinal	46	0.198
Brown-headed Cowbird	15	0.063	Northern Flicker*	33	0.135
Blue Jay	59	0.213	Northern Mockingbird	2	0.010
Brown Thrasher*	2	0.010	Pileated Woodpecker	12	0.058
Carolina Chickadee	13	0.058	Prairie Warbler	1	0.005
Carolina Wren	2	0.010	Red-bellied Woodpecker	47	0.217
Cedar Waxwing	2	0.010	Red-eyed Vireo	2	0.010
Cerulean Warbler*	1	0.005	Red-headed Woodpecker*	18	0.072
Chipping Sparrow	1	0.005	Red-tailed Hawk	2	0.010
Chimney Swift	1	0.005	Ruby-throated Hummingbird	6	0.019
Common Yellowthroat	27	0.116	Red-winged Blackbird	9	0.034
Downy Woodpecker	6	0.029	Song Sparrow	39	0.150
Eastern Phoebe	10	0.043	Summer Tanager	1	0.005
Eastern Towhee	52	0.227	Tree Sparrow	7	0.024
Eastern Wood-pewee	55	0.237	Tufted Titmouse	28	0.126
European Starling	20	0.082	Turkey Vulture	1	0.005
Field Sparrow*	71	0.275	White-breasted Nuthatch	2	0.010
Great Crested Flycatcher	5	0.024	Willow Flycatcher	1	0.005
Gray Catbird	46	0.184	Wood Thrush*	68	0.266
Henslow's Sparrow*	4	0.019	Yellow-breasted Chat	3	0.014
House Wren	6	0.024			

Table 1. Songbird species observed during songbird surveys in Highland County, OH during June-August of 2013 ("*" indicates a Federal Trust species; those with a frequency $\geq$ 10% are highlighted).

	Horizontal Visual Obstruction	Overhead Cover	Shrub Density
Control Plots			
Mean	61.98	22.60	3.67
Standard Deviation	19.52	19.02	4.33
95% Confidence Interval	8.44	8.22	1.87
Treated Plots			
Mean	81.00	4.70	4.08
Standard Deviation	13.85	6.97	5.98
95% Confidence Interval	4.11	2.07	1.78

Table 2. Summary statistics of horizontal visual obstruction, overhead cover, and shrub density on control and treated plots used in data analysis for songbird surveys in Highland County, OH during June-August, 2013.

Variables	Coefficients		Variables	Coefficients	
	Z value	P value		Z value	P value
American Robin			**Northern Cardinal**		
Treatment (edge feathered)	1.12	0.26	Treatment (edge feathered)	0.99	0.32
Site (Peach Orchard)	0.97	0.33	Site (Peach Orchard)	1.05	0.30
Treatment by Site	-1.62	0.10	Treatment by Site	-1.54	0.13
Blue Jay			**Red-bellied Woodpecker**		
Treatment (edge feathered)	0.60	0.56	Treatment (edge feathered)	-0.82	0.42
Site (Peach Orchard)	-0.66	0.51	Site (Peach Orchard)	-1.82	0.07
Treatment by Site	-0.20	0.84	Treatment by Site	0.56	0.58
Common Yellowthroat			**Song Sparrow**		
Treatment (edge feathered)	0.40	0.69	Treatment (edge feathered)	0.27	0.79
Site (Peach Orchard)	0.10	0.92	Site (Peach Orchard)	0.59	0.55
Treatment by Site	0.69	0.49	Treatment by Site	-0.79	0.43
Eastern Towhee			**Tufted Titmouse**		
Treatment (edge feathered)	-0.23	0.82	Treatment (edge feathered)	-0.60	0.55
Site (Peach Orchard)	-1.88	0.06	Site (Peach Orchard)	1.02	0.31
Treatment by Site	1.38	0.17	Treatment by Site	0.19	0.85
Eastern Wood-pewee			**Wood Thrush**		
Treatment (edge feathered)	0.61	0.54	Treatment (edge feathered)	-1.44	0.15
Site (Peach Orchard)	0.62	0.54	Site (Peach Orchard)	-0.12	0.90
Treatment by Site	-0.34	0.73	Treatment by Site	-0.36	0.72
Gray Catbird			**Field Sparrow**		
Treatment (edge feathered)	0.58	0.56	Treatment (edge feathered)	-0.19	0.85
Site (Peach Orchard)	-1.10	0.27	Site (Peach Orchard)	1.10	0.27
Treatment by Site	-0.04	0.97	Treatment by Site	-0.24	0.81
Indigo Bunting			**Northern Flicker**		
Treatment (edge feathered)	0.09	0.93	Treatment (edge feathered)	-0.11	0.91
Site (Peach Orchard)	0.53	0.59	Site (Peach Orchard)	1.42	0.15
Treatment by Site	-1.09	0.27	Treatment by Site	-0.54	0.59

Table 3. Results of a logistic regression model analyzing associations between the presence of songbirds and the interaction between treatment type and site location.

Variables	**Coefficients**	
Model 1	Z value	P value
Treatment (edge feathered)	0.00	1.00
Site (Peach)	0.00	1.00
Treatment by Site	0.00	1.00
Model 2		
Treatment (edge feathered)	0.59	0.56
Horizontal Cover	0.93	0.35
Overhead Cover	1.23	0.22
Shrub Density	-0.11	0.91

Table 4. Results of two Poisson regression models; Model 1 analyzes associations between total bird abundance and interactions between treatment type and site location; Model 2 analyzes associations between total bird abundance and interactions between horizontal cover, overhead cover, and shrub density.

Variables	Coefficients		Variables	Coefficients	
	Z value	P value		Z value	P value
American robin			**northern cardinal**		
Treatment (edge feathered)	-1.33	0.18	Treatment (edge feathered)	-0.37	0.71
Horizontal Cover	0.34	0.73	Horizontal Cover	-0.50	0.62
Overhead Cover	-1.20	0.23	Overhead Cover	-0.56	0.57
Shrub Density	-0.99	0.32	Shrub Density	-0.36	0.72
blue jay			**red-bellied woodpecker**		
Treatment (edge feathered)	0.53	0.60	Treatment (edge feathered)	-0.34	0.73
Horizontal Cover	0.35	0.73	Horizontal Cover	0.31	0.76
Overhead Cover	0.61	0.54	Overhead Cover	1.12	0.26
Shrub Density	-1.19	0.23	Shrub Density	1.98	0.05
common yellowthroat			**song sparrow**		
Treatment (edge feathered)	1.32	0.19	Treatment (edge feathered)	-0.58	0.56
Horizontal Cover	-1.29	0.20	Horizontal Cover	1.17	0.24
Overhead Cover	-1.22	0.22	Overhead Cover	0.87	0.38
Shrub Density	-0.58	0.56	Shrub Density	1.97	0.05
eastern towhee			**tufted titmouse**		
Treatment (edge feathered)	0.11	0.91	Treatment (edge feathered)	0.32	0.75
Horizontal Cover	0.07	0.94	Horizontal Cover	-1.74	0.08
Overhead Cover	-0.74	0.46	Overhead Cover	-0.70	0.48
Shrub Density	0.05	0.96	Shrub Density	-0.49	0.62
eastern wood-pewee			**wood thrush**		
Treatment (edge feathered)	1.61	0.11	Treatment (edge feathered)	-2.18	0.03
Horizontal Cover	-1.08	0.28	Horizontal Cover	0.52	0.61
Overhead Cover	0.75	0.46	Overhead Cover	0.47	0.64
Shrub Density	0.79	0.43	Shrub Density	-1.21	0.23
gray catbird			**field sparrow**		
Treatment (edge feathered)	0.04	0.97	Treatment (edge feathered)	-0.68	0.50
Horizontal Cover	1.22	0.22	Horizontal Cover	-0.10	0.92
Overhead Cover	0.62	0.53	Overhead Cover	-0.85	0.40
Shrub Density	-0.99	0.32	Shrub Density	-0.03	0.98
indigo bunting			**northern flicker**		
Treatment (edge feathered)	-1.40	0.16	Treatment (edge feathered)	-0.22	0.82
Horizontal Cover	1.99	0.05	Horizontal Cover	0.85	0.39
Overhead Cover	1.52	0.13	Overhead Cover	0.95	0.34
Shrub Density	-2.430	0.015	Shrub Density	-0.64	0.52

Table 5. Results of a logistic regression model analyzing associations between the presence of songbirds and the interactions between treatment type, horizontal cover, overhead cover, and shrub density.

APPENDIX

Rare Or Declining Species	Rare Or Declining Species (Continued)
Swainson's Hawk (*Buteo swainsoni*)	Prothonotary Warbler (*Protonotaria citrea*)
Upland Sandpiper (*Bartramia longicauda*)	Worm-eating Warbler (*Helmitheros vermivorum*)
Black-billed Cuckoo (*Coccyzus erythropthalmus*)	Swainson's Warbler (*Limnothlypis swainsonii*)
Short-eared Owl (*Asio flammeus*)	Louisiana Waterthrush (*Parkesia motacilla*)
Eastern Whip-poor-will (*Antrostomus vociferus*)	Kentucky Warbler (*Geothlypis formosa*)
Red-headed Woodpecker (*Melanerpes erythrocephalus*)	Canada Warbler (*Cardellina canadensis*)
Northern Flicker (*Colaptes auratus*)	Bachman's Sparrow (*Peucaea aestivalis*)
Olive-sided Flycatcher (*Contopus cooperi*)	Field Sparrow (*Spizella pusilla*)
Acadian Flycatcher (*Empidonax virescens*)	Grasshopper Sparrow (*Ammodramus savannarum*)
Willow Flycatcher (*Empidonax traillii*)	Baird's Sparrow (*Ammodramus bairdii*)
Loggerhead Shrike (*Lanius ludovicianus*)	Henslow's Sparrow (*Ammodramus henslowii*)
Bell's Vireo (*Vireo bellii*)	Le Conte's Sparrow (*Ammodramus leconteii*)
Bewick's Wren (*Thryomanes bewickii*)	Nelson's Sparrow (*Ammodramus nelsoni*)
Sedge Wren (*Cistothorus platensis*)	Painted Bunting (*Passerina ciris*)
Marsh Wren (*Cistothorus palustris*)	Dickcissel (*Spiza americana*)
Wood Thrush (*Hylocichla mustelina*)	Bobolink (*Dolichonyx oryzivorus*)
Brown Thrasher (*Toxostoma rufum*)	Rusty Blackbird (*Euphagus carolinus*)
Sprague's Pipit (*Anthus spragueii*)	Orchard Oriole (*Icterus spurius*)
Chestnut-collared Longspur (*Calcarius ornatus*)	**Game Birds**
Smith's Longspur (*Calcarius pictus*)	Northern Bobwhite (*Colinus virginianus*)
Blue-winged Warbler (*Vermivora cyanoptera*)	Ring-necked Pheasant (*Phasianus colchicus*)
Golden-winged Warbler (*Vermivora chrysoptera*)	Mourning Dove (*Zenaida macroura*)
Prairie Warbler (*Setophaga discolor*)	American Woodcock (*Scolopax minor*)
Cerulean Warbler (*Setophaga cerulea*)	

Table 1. Federal Trust bird species known to reside or breed in or near Highland County, OH.

Point	Horizontal Visual Obstruction (%)	Overhead Cover (degrees)	Shrub Density (m^2)
CF01	76.25	25.50	2.7992
CF02	40.80	56.00	3.7635
CF03	85.45	8.00	4.1428
CF04	55.36	17.75	2.0256
CF05	44.29	33.25	0.3980
CF06	83.48	3.25	18.9971
CF07	84.64	5.00	8.7436
CF08	95.27	6.50	1.2378
CF09	38.84	8.75	1.2143
CF10	28.93	75.75	0.5856
CF11	55.09	9.00	10.9133
CF12	86.88	22.50	2.4955
CP01	52.68	17.75	0.8789
CP02	77.95	18.75	1.9492
CP03	53.30	14.50	5.7730
CP04	67.86	19.00	1.8488
CP05	64.29	24.25	0.7166
CP06	83.93	50.25	0.3256
CP07	65.45	9.50	5.5759
CP08	35.54	49.25	4.7690
CP09	37.41	30.75	3.8723
CP10	63.66	3.25	1.4825
CP11	48.30	11.25	0.0143

Table 2. Horizontal visual obstruction, overhead cover, and shrub density data for control plots used in data analysis for songbird surveys carried out in Highland County, OH during the June-August of 2013.

Point	Horizontal Visual Obstruction (%)	Overhead Cover (degrees)	Shrub Density (m^2)	Point	Horizontal Visual Obstruction (%)	Overhead Cover (degrees)	Shrub Density (m^2)
F03	94.84	0.00	6.11	**P33**	93.97	0.00	4.99
F05	93.58	0.00	8.22	**P35**	71.21	7.50	0.39
F17	86.75	0.00	20.24	**P37**	63.94	5.38	1.50
F19	88.93	2.13	4.25	**P39**	79.61	0.25	0.30
F24	95.06	1.00	0.86	**P41**	67.73	10.75	0.09
F27	94.63	0.00	4.44	**P43**	81.96	10.50	0.16
F31	83.79	9.25	1.06	**P45**	79.96	8.50	1.20
F35	86.88	8.38	5.31	**P47**	51.80	16.00	0.30
F45	88.45	4.13	4.31	**P49**	87.92	0.00	1.29
F51	81.48	2.25	1.77	**P51**	72.65	2.00	2.66
F57	78.09	0.00	0.92	**P53**	82.79	0.00	29.70
F67	95.06	1.25	7.34	**P55**	68.99	7.88	1.61
F70	72.04	10.13	1.20	**P57**	94.19	1.75	4.70
F76	90.27	1.50	1.05	**P61**	94.41	3.38	1.24
F82	94.24	0.00	15.32	**P65**	64.03	1.25	0.21
F88	94.63	0.00	10.84	**P67**	80.79	0.00	0.80
F92	93.15	0.00	16.99	**P71**	92.10	0.00	0.13
P05	84.75	2.25	0.56	**P73**	66.42	10.13	0.91
P09	39.13	27.50	0.09	**P75**	79.61	4.50	0.96
P13	45.18	21.38	0.13	**P81**	82.14	3.13	0.95
P17	53.76	28.88	1.12	**P83**	88.40	0.63	0.89
P25	84.83	2.50	2.72	**P85**	90.27	0.00	4.50
P29	85.66	0.00	8.11	**P87**	86.10	0.00	5.02

Table 3. Horizontal visual obstruction, overhead cover, and shrub density data for treated plots used in data analysis for songbird surveys carried out in Highland County, OH during June-August of 2013.